REPORT

ON THE

Cawnpore Farm and other Experiment Stations

IN THE

UNITED PROVINCES

FOR THE YEAR ENDING JUNE 30TH, 1904.

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From

W. H. MORELAND, Esq., I.C.S.,

Director of Land Records and Agriculture,

United Provinces,

To

The CHIEF SECRETARY to GOVERNMENT,

United Provinces.

Dated Cawnpore, the 29th of August 1904.

Sir,

I have the honour to submit for the information of Government the report on the Cawnpore farm and other experiment stations in the United Provinces for the year ending June 30th, 1904.

I have the honour to be,

Sir,

Your most obedient servant,

W. H. MORELAND,

Director.

Report on the Cawnpore Farm and other Experiment Stations for the year ending June 30th, 1904.

CHAPTER I.

Field experiments conducted at the Cawnpore Farm.

1.—HISTORY.

THE farm is situated in the village of Gotaiya, about three miles from Cawnpore; it is within a few yards of the Rawatpur station on the Cawnpore-Achnera Railway, and at a distance of about four miles from the East Indian Railway and five miles from the Oudh and Rohilkhand Railway stations. The land occupied was originally rented from the land-holders and tenants of Gotaiya in 1881 and in that year the important manurial experiments still carried on in the "standard" and "duplicate" series, which will be described presently, were started by Mr. J. B. Fuller, then Assistant Director of this Department. The ownership of the whole area has been acquired by Government.

During the early years of management the area of the farm underwent frequent changes; but of late it has not varied, and is 51·33 acres in extent, of which 36·34 acres are under cultivation and the rest is occupied with roads, watercourses, and farm buildings. Of the cultivated area about six acres consist of small corner plots or irregular fields, unsuitable for experimental work, and this area is utilized for raising fodder for the farm cattle. The whole area of the farm is irrigable from a distributary of the Ganges Canal, and is thus well protected against seasons of drought or deficient rainfall.

The soil of the farm may be accepted as a fair sample of the alluvial loam which occurs over a large portion of the Ganges-Jumna Doáb. Though, according to the analyses made in 1882 by the late Mr. S. A. Hill, B.Sc., it contains 78·56 per cent. of insoluble sand, yet owing to the fineness of the particles its physical characters are those of a loam. The soils of a good many plots of the farm have been analysed by the Agricultural Chemist to the Government of India, and the following table gives the composition of five unmanured plots as regards the three dominant agricultural ingredients (*vide* page 54, Agricultural Ledger No. 2 of 1898):—

Composition of the soils of the unmanured plots of the farm.

Name of plot.	Total nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Available potash.
	Per cent.	Per cent.	Per cent.	Per cent.
Rabi standard, No. 11... ...	·024	·085	·021	·012
Kharíf standard, No. 13 ...	·016	·053	·022	·007
Alternate series A, No. 13 ...	·017	·088	·030	·007
Alternate series B, No. 11 ...	·023	·071	·014	·012
Green manure series, No. 5 ...	·017	·053	·015	·027
Average	·019	·070	·020	·013

Chemical analysis and practical experience concur in showing that there is no abnormal deficiency of lime or any other plant-food ingredients.

2.—CHARACTER OF THE SEASON.

Vide appendices I and II.

The year was not on the whole unfavourable, though only 1·9 inches of rain fell in June and ·77 in July, and consequently the general kharíf sowings were much delayed, while what was sown with the light June rains hardly survived, and the sugarcane suffered a good deal from the prolonged hot weather. During August and September the rain fell very evenly, the constant small showers proving most beneficial to the kharíf crops and greatly facilitating the tillage for the rabí, but this was followed by untimely and excessive rain in October, which delayed the rabí sowings and did great damage to the cotton. On the other hand it left the land sufficiently supplied with moisture to carry it through the rest of the cold season which was rather dry. Rust occurred but was not bad; more damage was done by hot west winds occurring before the crops were ripe. White-ants did a good deal of harm to the wheat early in the cold season in spite of the unusual amount of water in the soil, but when they ceased to attack, the plants stooled out and the crop generally recovered itself, especially where the land was in good condition.

3.—MANURIAL EXPERIMENTS.

The following manurial experiments were carried on during the past year :—

Name.	Crop.	Number of plots.	Area in acres.	Duration of experiments.
1. Kharíf standard ...	Maize every year ...	13	1·07	Permanent.
2. Rabí standard ...	Wheat ditto ...	13	1·07	
3. Duplicate or alternate series A.	Maize and wheat alternately.	13	1·07	
4. Ditto B ...	Ditto ...	13	1·07	
5. Green manuring and Rotation experiment	Various	4	·70	
	Ditto	14	2·33	
	Total ...	70	7·31	

Maize and wheat.—The first four experiments are carried on in four series of 13 plots each, *i.e.* on 52 plots in all. When originally started in 1881 by Mr. J. B. Fuller, there were only ten plots in each series, and the remaining three plots were subsequently added in 1882 and 1883. Since then there has been no change in the number of plots. One series is cropped every year with maize, another with wheat, and these two are called kharíf and rabí standard series respectively. In the other two series known as "alternate series" maize and wheat are grown in rotation in alternate years. Thus the maize crops on the kharíf standard plots get every year a fallow of about nine months, while those on the duplicate plots, a fallow of only about two months after the previous crops of wheat is cut. But as regards wheat the rabí standard plots get a fallow of six months against the 13 months on the duplicate plots. Owing to this reason the maize on the standard plots is, as a rule, better than on the duplicate plots, while the wheat on the alternate plots is better, though the difference is less marked and less certain than is the case with maize. The manure applied to one plot of the standard series is also applied to the corresponding plot of the duplicate series. The object of the kharíf and rabí standard series is to ascertain the effects and establish the relative values of certain manures on maize and wheat grown year after year on the same land. The object of the alternate series is to some extent to duplicate these trials, and also to study the effects and economy of alternation of maize with wheat.

The scheme of treatment of these plots was changed five years ago at the instance of the Agricultural Chemist to the Government of India. The old and new schemes, as well as the compositions and quantities of manures applied during the year under report, are given in the next table.

Table showing the old and new schemes of treatment and composition and quantities of manures.

No. of plot.				Old treatment.	New treatment.	Composition and quantities of manures applied per acre in 1903-04.			
						Maize.		Wheat.	
Rabí standard.	Alternate B.	Kharíf standard.	Alternate A.			Percentage of nitrogen.	Quantity of manure applied.	Percentage of nitrogen.	Quantity of manure applied.
							lbs.		lbs.
R.3	3	K.3	6	Cattle manure @ 180 mds. per acre.	Cattle manure to supply 100lbs. nitrogen per acre ...	·41	24,390	·30	33,333
R.4	4	K.1	7	Cattle manure and bone-dust @ 4½ mds. per acre.	Cattle manure to supply 50lbs. nitrogen per acre ...	·41	12,195	·30	16,666·5
R.5	5	K.2	8	Cattle manure and gypsum @ 3 mds. per acre.	No manure ...	...	...	...	...
R.6	6	K.10	1	Sheep-dung @ 180 mds. per acre.	Sheep-dung to supply 100lbs. nitrogen per acre ...	1·22	8,196	·95	10,526
R.8	8	K.7	10	Sheep-dung and bone-dust @ 4½ mds. per acre.	Sheep-dung to supply 50lbs. nitrogen per acre ...	1·22	4,098	·95	5,263
R.10	10	K.12	12	Sheep-dung and gypsum @ 3 mds. per acre.	Poudrette to supply 50lbs. nitrogen per acre ...	·52	9,615	·30	16,666·5
R.12	12	K.9	2	Poudrette @ 180 mds. per acre.	Poudrette to supply 100lbs. nitrogen per acre ...	·52	19,230	·30	33,333
R.1	1	K.5	4	Saltpetre @ 3 mds. per acre.	Saltpetre to supply 25lbs. nitrogen per acre ...	11·55	216	11·19	223
R.2	2	K.11	5	Saltpetre and bone-dust @ 4½ mds. per acre.	Saltpetre to supply 25lbs. nitrogen per acre ... } Bone-dust to supply 10lbs. nitrogen per acre ... } 35lbs. nitrogen per acre.	11·55	216	11·19	223
						3·71	269	3·72	268
R.9	9	K.6	11	Saltpetre and bone-superphosphate, each @ 3 mds. per acre.	Saltpetre to supply 25lbs; Bone-superphosphate 10lbs ... } 35lbs. nitrogen per acre.	11·55	216	11·19	223
						2·66	375	2·56	390
R.7	7	K.4	9	Ashes of 180 mds. of cow-dung per acre.	Ashes of 180 mds. of cow-dung per acre	...	6,053	0·23	5,929
R.13	13	K.8	3	Ashes and saltpetre @ 3 mds. per acre.	Ashes and saltpetre to supply 25lbs. nitrogen per acre ...	11·55	{ 6,053 216 }	11·19	{ 5,929 211 }
R.11	11	K.13	13	Unmanured ...	Unmanured ...	...	...	...	...

Maize.—The two series bearing maize were treated as follows:—

Ploughed twice, subsoiled once, cultivated with the planet Jr. cultivator twice, and levelled with the *patela* four times. The manures were applied at one time in July, except saltpetre, which was applied as a top dressing in two instalments on the 5th and 24th of August. Seed was dibbled on the 22nd and 23rd of July, in holes two feet by one foot apart from each other at the rate of three or four seeds to the hole to guard against contingencies of uneven germination; the rate of seed coming to about 24lbs per acre. When the plants were about a week old the crop was thinned and blanks filled in, weeded and hoed twice and earthed up once. The outturns are shown in the following table:—

Acreage outturns (in lbs.) of dry maize

Plot area.	Year.	Cow-dung at 100lbs. nitrogen per acre.		Cow-dung at 50lbs. nitrogen per acre.		Residue of cow-dung applied in previous years.		Sheep-dung at 100lbs. nitrogen per acre.		Sheep-dung at 50lbs. nitrogen per acre.		Poudrette at 100lbs. nitrogen per acre.	
		Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.
Each plot is equal to 400 square yards.	* Average of five years, 1883 to 1886 and 1889.	1,211	1,119	1,442	1,114	1,261	1,006	876	1,003	1,285	880	1,255	1,282
	Average of five years, 1890 to 1894.	996	744	1,303	906	1,471	906	1,330	1,483	1,529	1,184	1,096	1,528
	1895 ...	2,018	1,004	1,900	1,110	2,105	1,140	2,668	1,189	2,344	1,186	1,945	2,027
	1896 ...	2,541	1,156	1,700	1,385	1,706	1,210	2 813	1,706	2,378	1,809	2,148	1,428
	1897 ...	3,158	2,989	3,243	1,422	3,424	2,452	3,733	1,972	3,025	3,633	3,527	1,794
	1898 ...	1,609	1,343	2,105	1,779	2,226	1,682	2,093	2,009	1,654	1,888	2,323	1,984
	1899 ...	1,634	1,701	2,136	1,331	2,202	1,579	2,393	1,246	2,707	1,516	2,426	2,490
	Average of five years, 1895 to 1899.	2,192	1,639	2,217	1,405	2,333	1,613	2,740	1,624	2,418	2,006	2,474	1,945
	1900 ...	2,698	2,420	3,064	2,641	3,167	2,426	2,989	2,605	3,228	2,559	2,940	2,892
	1901 ...	2,538	2,417	2,368	2,017	2,704	1,833	2,468	2,368	3,133	2,102	2,565	2,725
	1902 ...	1,283	1,343	1,700	1,621	1,700	1,301	1,694	1,125	1,942	1,240	1,930	1,331
	1903 ... Grain...	2,889	2,402	2,862	2,096	2,477	1,346	2,665	2,859	3,010	1,863	2,910	3,191
	1903 ... Straw...	5,687	2,420	2,710	2,287	2,674	1,906	1,815	2,408	2,493	1,742	2,807	2,783

NOTE *(1)—The figures for single years from 1882—1894
(2)—The years 1887 and 1888 are excluded from the

grain in the standard and alternate series.

Poudrette at 50lbs. nitrogen per acre.		Saltpetre at 25lbs. nitrogen per acre.		Saltpetre at 25lbs. nitrogen and bone-dust at 10lbs nitrogen per acre.		Saltpetre at 25lbs. nitrogen and bone-superphosphate at 10lbs. nitrogen per acre.		Ashes of 180 maunds of cow-dung per acre.		Ashes of 180 maunds of cow-dung and saltpetre at 25 lbs. nitrogen per acre.		No manure.		Remarks.
Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	
1,146	957	1,099	757	1,174	931	1,052	881	821	628	1,207	1,130	617	413	
1,367	1,067	794	778	899	952	1,212	872	682	683	1,276	984	695	570	
2,232	1,325	850	787	1,437	1,089	1,624	898	995	750	1,703	1,007	1,059	774	Alternate B.
2,035	2,021	1,119	714	1,065	430	877	375	1,349	607	910	853	472	200	Do. A.
3,225	2,372	2,544	2,228	2,695	2,493	2,816	1,410	2,411	2,133	2,713	2,015	2,021	1,857	Do. B.
2,396	2,105	1,295	1,222	2,614	1,309	1,888	1,162	1,210	956	2,033	1,730	1,307	460	Do. A.
2,420	2,045	1,997	717	2,329	1,125	1,945	1,237	1,664	871	2,169	1,773	1,476	1,177	Do. B.
2,462	1,974	1,561	1,134	2,028	1,289	1,830	1,016	1,526	1,063	1,906	1,476	1,267	894	
3,182	2,974	2,190	2,257	2,151	2,438	2,738	2,184	1,755	1,712	2,202	2,166	1,682	690	Do. A.
2,925	2,009	2,396	1,912	2,244	2,175	2,196	1,963	1,464	1,452	2,314	2,154	1,730	1,249	Do. B.
2,099	1,997	1,281	1,295	1,915	1,392	1,246	1,310	1,895	750	1,470	1,131	1,316	889	Do. A.
2,968	2,611	2,000	1,860	2,290	2,299	2,021	1,782	1,092	1,219	1,933	1,803	1,080	959	Do. B.
2,880	2,287	2,977	2,420	2,444	2,650	2,638	2,045	2,432	1,960	2,553	2,735	1,876	1,694	

will be found in the report for 1900-1901.
average as the crops were almost entire failures.

Wheat.—The two series bearing wheat were treated as follows: ploughed four times, subsoiled once, spread on 29th October 1903 except saltpetre, which was applied in two instalments, on 27th November and rate of about 120lbs. per acre and the land levelled. The crop was weeded once, watered thrice, and harvested

Acreage outturns (in lbs.) of wheat grain

Plot area.	Year.	Cow-dung at 100lbs. nitrogen per acre.		Cow-dung at 50lbs. nitrogen per acre.		Residue of cow-dung applied in previous years.		Sheep-dung at 100lbs. nitrogen per acre.		Sheep-dung at 50lbs. nitrogen per acre.		Poudrette at 100lbs. nitrogen per acre.	
		Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.
Each plot is equal to 400 square yards.	Average for five years, 1885 to 1889.	1,184	1,394	1,338	1,339	1,258	1,361	1,219	1,517	1,051	1,511	1,253	1,642
	Average for six years, 1890 to 1895.	1,613	1,743	1,685	1,606	1,560	1,581	1,691	1,690	1,694	1,954	1,653	1,792
	1896 ...	2,765	2,184	2,910	1,900	2,904	250	3,001	3,120	3,206	3,104	2,819	3,092
	1897 ...	2,558	2,729	2,472	2,553	2,558	2,716	2,967	2,868	2,107	2,777	2,889	3,219
	1898 ...	2,384	2,202	2,880	2,239	2,069	2,021	2,543	2,880	2,396	2,565	2,202	2,372
	1899 ...	2,184	2,505	2,363	2,384	2,166	2,217	2,505	2,741	2,232	3,028	2,245	2,356
	1900 ...	2,729	2,795	2,937	2,456	2,659	2,229	3,089	3,004	2,741	2,816	2,490	2,598
	Average for five years, 1896 to 1900.	2,524	2,483	2,712	2,306	2,471	2,339	2,821	2,923	2,536	2,858	2,529	2,727
	1901 ...	1,485	1,906	1,652	2,021	1,337	1,960	1,797	1,688	1,431	1,936	1,367	1,676
	1902 ...	2,565	3,031	2,686	2,952	2,450	2,426	2,075	2,396	2,414	3,037	2,166	2,608
	1903 ...	2,595	3,243	2,493	2,704	2,456	2,771	3,061	2,698	2,813	3,606	2,184	3,285
	1904... Grain...	1,930	2,856	2,644	2,559	2,003	2,281	2,626	3,019	1,694	2,547	2,245	2,856
	1904... Straw...	3,624	6,117	3,092	4,277	3,618	3,769	5,052	5,862	3,098	5,826	4,005	5,893

NOTES * (1)—About a third of this plot has the disadvantage of
(2)—The figures for 1883 and 1884 are purposely left out
(3)—The figures for single years, from 1885—1895, will

cultivated with the planet Jr. cultivator once, and levelled three times with the *patela*. The manures were 23rd December, as a top dressing. The seed was sown with the country plough on 31st October at the on 11th to 14th April. The results of the last and of the previous years are given in the following table :—

in the standard and alternate series.

Poudrette at 50lbs. nitrogen per acre.		Saltpetre at 25lbs. nitrogen per acre.		Saltpetre at 25lbs. nitrogen and bone-dust at 10lbs. nitrogen per acre.		Saltpetre at 25lbs. nitrogen and bone-superphosphate at 10lbs. nitrogen per acre.		Ashes of 180 maunds of cow-dung per acre.		Ashes of 180 maunds of cow-dung and saltpetre at 25lbs. nitrogen per acre.		No manure.		Remarks.
Standard.	Alternate.	Standard.*	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	
1,177	1,325	1,314	1,406	1,398	1,726	1,131	1,557	829	1,246	1,208	1,405	888	1,082	
1,797	1,874	1,481	1,573	1,484	1,748	1,681	1,704	1,339	1,448	1,568	1,731	1,104	1,308	
3,146	2,983	1,839	2,353	2,063	1,516	2,426	1,927	2,202	2,090	2,396	2,408	2,257	1,183	Alternate A.
2,466	2,952	1,853	2,535	1,948	2,589	2,236	2,559	1,757	1,785	2,188	2,474	1,723	1,936	Do. B.
2,263	2,553	1,851	2,045	2,154	2,263	2,468	2,360	1,742	1,307	1,827	2,142	1,416	1,246	Do. A
2,680	2,898	2,242	2,608	2,287	2,689	2,360	2,602	1,851	1,761	1,567	1,597	1,386	1,658	Do. B.
3,004	2,952	2,323	2,768	2,420	2,592	2,961	2,704	2,154	1,779	2,251	2,444	1,951	1,500	Do. A.
2,712	2,868	2,022	2,462	2,174	2,330	2,490	2,430	1,941	1,744	2,046	2,213	1,747	1,505	
1,434	1,588	1,077	2,118	1,379	1,960	1,621	1,821	1,071	1,473	1,506	1,900	1,189	1,410	Do. B.
2,719	2,810	2,220	2,577	2,205	2,668	2,650	2,771	2,353	2,565	2,323	2,335	1,936	1,724	Do. A.
2,305	3,285	1,773	2,502	2,093	2,045	3,025	2,910	1,894	2,118	2,066	2,886	2,366	1,969	Do. B.
2,481	2,523	1,470	2,595	1,821	2,874	2,390	2,934	1,150	2,317	2,208	2,287	1,476	1,059	Do. A.
4,374	5,070	2,819	4,652	3,709	4,943	4,150	5,536	2,105	4,035	2,644	4,150	2,402	1,845	

adjoining trees, and bears every year a strikingly poorer crop than the rest of the plot.
of account.
be found in the report for 1900-1901.

Experiments included under nitrogen investigations.

As mentioned in last year's report, the green-manuring and rotation experiments have been revised; four of the green-manuring plots have been retained, and a number of rotation plots laid out close to them.

The scheme of the experiment, which was fully discussed with the Inspector-General of Agriculture, now stands as follows:—

(*A*) *Two-year rotations.*

Two plots.—Wheat and gram in alternate years.
Two plots.—Wheat and *juar-arhar* in alternate years.
One plot.—Wheat and *juar-urd-lubia* in alternate years.
Two plots.—Wheat and *juar* in alternate years.
One plot.—Wheat every year.
One plot.—Wheat and mustard every year.
One plot.—Wheat-gram every year.

(*B*) *Dofasli rotations.*

One plot.—Wheat after hemp removed.
One plot.—Wheat after *urd*-fodder removed.
One plot.—Wheat after *khurti*-fodder removed.
One plot.—Maize (country) followed by wheat in the same year.

(*C*) *Green-manuring.*

Wheat after hemp ploughed in.
Wheat after *khurti* ploughed in.
Wheat after *urd* ploughed in.
Wheat every year.

Details of cultivation.—In the kharíf, the plots under two-year rotations growing *juar*, etc., were ploughed twice and levelled once; the *dofasli* and green-manuring plots were ploughed and levelled once. The *juar* plots were sown on 5th August, the others between July 21st and 24th. All were sown broadcast except the maize, which was dibbled by hand.

In the green-manuring experiment the standing crops were ploughed in on September 1st, while in the *dofasli* they were removed on the same date. The maize plot was weeded twice and earthed up once: all the *dofasli* and green-manuring plots were watered once with the exception of the *khurti*-fodder plot for which water was not available.

In the rabí all plots except the green-manuring group, which were ploughed four times, were ploughed five times, and cultivated once: levellings varied from three to five according to the needs of the plot. Seed was sown on 4th October and all plots weeded once. The wheat plots were watered three times, the gram once.

The outturns are given in the following table:—

ROTATION AND GREEN-MANURING EXPERIMENT.

Outturns in pounds per acre, 1902-1903 *and* 1903-1904.

Field No.	Area.	Treatment.	Crop.	1902-1903.		1903-1904.	
				Kharif.	Rabi.	Kharif.	Rabi.
		(A) Two-year rotations.					
31—33/1	1/6th acre ...	Wheat and gram ...	Wheat ...	...	3,546	...	...
			Gram ..	...	...	...	1,878
31—33/2	„	Gram and wheat ...	Gram ...	...	1,485	...	..
			Wheat ...	...	...	...	2,754
31—33/4	„	Wheat and *juar-arhar*...	Wheat ...	...	2,562	...	...
			Juar ...	...	...	608	...
			Arhar ...	...	...	1,086	...
31—33/3	„	*Juar-arhar* and wheat ...	*Juar* ...	387	...	...	...
			Arhar ...	606	...	...	...
			Wheat ...	...	...	...	2,282
31—33/10	„	*Juar-urd-lobia* and wheat	*Juar* ...	390	...	...	...
			Urd ...	30	...	...	...
			Lobia ...	12	...	...	...
			Wheat ...	...	...	...	2,232
31—33/12	„	*Juar* and wheat ...	*Juar* ...	402	...	...	...
			Wheat ...	...	...	...	1,647
31—33/13	„	Wheat and *juar* ...	Wheat ...	...	2,076	...	...
			Juar ...	...	...	560	...
31—33/5	„	Wheat (every year) ...	...	...	2,733	...	1,602
31—33/9	„	Wheat and mustard (every year).	Wheat ...	...	1,949	...	1,806
			Mustard ...	...	411	...	153
31—33/11	„	Wheat and gram (every year) *.	...	...	...	...	1,755
		(B) Dofasli rotations.					
31—33/6	„	Hemp fibre-wheat † ...	...	...	2,259	...	1,479
31—33/7	„	*Urd* fodder-wheat ...	...	8,400	1,692	11,088	1,338
31—33/8	„	*Khurti* fodder-wheat ...	...	6,888	1,341	3,276	1,173
		Maize-wheat * ...	...	...	...	1,358	1,080
		(C) Green-manuring plots.					
27A/1	778 square yards.	Wheat (after hemp) ...	...	...	980	...	1,017
27A/2	„	Wheat (after *khurti*) ...	...	...	818	...	1,166
27A/3	940 square yards.	Wheat (after *urd*) ...	...	...	835	...	1,038
27A/4	890 square yards.	Wheat	...	...	481	...	1,151

* Not sown in 1902-1903.

† Outturn of fibre not determined in 1902 or 1903.

4.—TRIALS OF DIFFERENT VARIETIES OF CROPS.

Sugarcane varieties.—This experiment was continued on the lines followed in former years; but, partly as the result of continuous cropping, partly owing to the season, and partly owing to the ravages of white-ants and borers, the outturns are not worth recording.

Besides the above experiment some Mauritius cane (imported), a few of the best canes of these Provinces and two from Bengal are being grown on small plots for observation and comparison.

Potatoes.—The three varieties under trial are (1) Madrasi white, (2) country red, and (3) hill variety. In the year under report, country red variety could not be sown as seed potatoes could not be procured.

Details of cultivation.—Tillage: ploughed twice, cultivated once and levelled four times. Poudrette at 200lbs. nitrogen per acre was applied on 10th to 13th November 1903. On 10th and 14th November 1903 whole tubers of the Madrasi variety and cut sets and whole tubers of the hill variety were dibbled in holes made with khurpis in regular lines on the flat ground. These lines were subsequently made into ridges by throwing earth over them. The distance between the ridges for the Madrasi was 20 inches apart and between the holes in the rows 10 inches, while for the hill variety the rows were 21 inches apart and the seed in the rows one foot apart. The weight of the seed used for the Madrasi variety came to 872 lbs. per acre, and that for the hill variety to 1,200lbs. The crop was earthed up once and watered five to seven times according to the needs of the plots; the hill potato was weeded twice. The crop was harvested on different dates between 29th February and 22nd April 1904.

The outturns are given in the next table. The experiment is now closed and the results will be discussed in a separate publication.

Statement showing the outturn of different varieties of potato.

Plot No.	Plot area.	Name of variety.	Outturn per acre.						Average outturn of six years of Madrasi and hill varieties and of five years of country red variety.
			1898-1899.	1899-1900.	1900-1901.	1901-1902.	1902-1903.	1903-1904	
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
26A/1	Each plot= 1,210 square yards.	Madrasi white.	12,928	16,660	16,152	10,908	13,808	10,708	13,527
26A/2		Country red.	11,772	19,700	17,312	11,300	5,512	...	13,119
26A/3		Hill variety.	10,016	11,488	16,596	5,780	4,304	3,090	8,546

Regarding the difference of time in germination remarked on in previous reports, the earliest sprouts of the Madrasi were noticed on the 12th day after planting and those of the hill variety on 21st day.

Cotton.—The lateness of the rains made it impracticable to grow the acclimatized cottons on an extensive scale, and only small plots were sown to maintain our supply of seed.

Juar.—The study of this crop continued during the year, and further progress was made in determining and classifying the varieties, but the work is not complete. An interesting observation is that the varieties appear to differ widely in liability to injury from the borer; this point requires more detailed study.

Maize.—Two common North Indian varieties and four American varieties were cultivated and kept under observation. The varieties were again grown in plots, separated by wide spaces with *juar* between, to guard against natural cross-fertilization. The American varieties have now had an extensive trial and show no sort of superiority over the indigenous varieties; the trials are now closed. The names under which the varieties were received are as follows:—

1. Extra early Waterloo Dent Field corn.
2. Blounts' Prolific Field corn.
3. King Philip Field corn.
4. Sweet corn.

Kabuli gram.—During the last six years this crop has been cultivated on a small area with the object of studying its habits and characters as compared with the ordinary gram, and of raising a small quantity of seed for supply to the public. The grain is white, larger, fuller and smoother, and presents a more attractive appearance than the ordinary gram. The plants also are larger and bushy with larger leaves and white flowers and with roots better provided with tubercles than even the country gram which is one of the best of our crops in this respect. The variety is, however, deficient in grain-yielding power as compared with the country kind. On the average of the past six years the outturn has been 1,050 lbs per acre, while country gram grown under the same conditions has averaged 1,638 lbs per acre; the latter has given the higher produce in every year,

and there can be no doubt that it is the more profitable crop for the soil and climate of Cawnpore. The trials have now been discontinued.

5.—MISCELLANEOUS EXPERIMENTS.

Deep and shallow tillage.—This experiment was started in its present form in 1901. The scheme is as follows:—

There are three plots, the area of each of them being one-fourth of an acre, each plot receiving cow-dung at the rate of 100 lbs. nitrogen per acre. The tillage operations are: for plot No. 1, subsoiling twice, 8″ to 9″ deep, followed by two ploughings with the country plough; for plot No. 2, ploughing twice with the Watt's plough, 5″ deep, followed by two ploughings with the country plough; for plot No. 3, eight ploughings with the country plough. The only other implement that was used on these plots was the *patah*. The seed was sown with the country plough, and the land levelled with the *patah*.

The outturns obtained are as follows:—

Acreage outturn of wheat on plots ploughed in three different ways.

Year.		Plot No. 1 subsoiled 8″ deep.	Plot No. 2 ploughed 5″ deep.	Plot No. 3 ploughed 4″ deep.
1901	... ...	960	813	779
1902	... ...	1,692	1,756	1,455
1903	... ...	1,582	1,530	1,617
1904	Grain ...	2,090	1,900	2,058
	Straw ...	3,078	2,836	2,794

Early and late sowing of Jaunpur maize.—This experiment was started in 1887, having for its object the determination of the effect of early and late sowing on the yield of this maize. The experiment is carried out in three plots, each of 807 square yards. The dates of sowing in 1903 were 31st May, 23rd July and 2nd August. Farm yard manure was applied at the rate of 200 maunds per acre. The early sown plot suffered much from deficiency of rainfall in the months of July and August, though it was watered thrice in June and July; but the other two did not suffer as the rain fell just at the time when it was wanted. The following statement shows the outturn obtained:—

The early and late sowing of maize.

Plot number.	Time of sowing.	Outturn per acre.												
		Average of 1887-88 to 1891-92.	1892-93.	1893-94.	1894-95.	1895-96.	1896 97.	1897-98.	1898-99.	1899-00.	1900-01.	1901-02.	1902-03.	1903-04.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
A. C 1	Early ...	1,551	1,678	1,825	213	553	260	1,532	1,809	1,032	2,418	1,941	1,563	989
17A.	Intermediate	1,169	1,928	1,591	276	1,053	1,322	1,132	1,608	716	2,616	1,845	1,020	2,168
A. C 2	Late ...	...	...	...	...	...	...	...	762	282	2,096	1,623	...	2,330

This experiment is now closed. The figures show quite clearly that an extra yield of maize cannot be counted on by sowing with irrigation before the rains break: whether the yield is greater or less than that of maize sown at the usual time is purely a question of season. Thus in 1899 the late sown crop was almost a complete failure owing first to excessive rain and then to prolonged drought; while in 1903 the delay in the arrival of the rains made the early-sown crop poor, and the late sown crop, favoured by seasonable weather, did very well. In approximately normal years such as 1900, there is no great gain in yield from sowing early, certainly not enough to cover the extra expense involved in this method of cultivation.

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It follows that cultivators who adopt it must be influenced by motives other than the amount of yield. One motive is no doubt insurance against an early cessation of the rains: the year 1899 is an instance of how this works. The other motive is to get the grain as early as possible, whether for home consumption at a time when the stock of food is low, or to sell at the top of the market before the ordinary harvest has begun to bring down prices.

Cotton and maize in alternate rows.—The results of this experiment are not worth recording: as has been said above, the lateness of the rains made it almost impossible to grow cotton successfully, and the attacks of insects destroyed what cotton was produced. The experiment is being repeated on a larger scale during the present year.

Raising pedigree maize.—Two varieties, Jaunpur maize and American yellow Dent Field corn, are being cultivated in order to raise pedigree strains. The experiment was started in 1900. The cultivation was generally similar to that adopted in the other maize plots on the farm. Each year seed is selected from the plants containing the best and most numerous cobs.

Jaunpur maize.	Outturn. lbs.
1900	1,980
1901	4,800
1902	2,260
1903	3,500
Dent Field corn (American).	
1900	1,445
1901	3,060
1902	1,720
1903	3,020

Protection of sugarcane sets against white-ants.—Four plots were sown with ordinary thin canes; the sets were treated in the following manner:—

Plot I—Copper sulphate and lime mixture sprinkled over sets.

Plot II—Sets soaked in copper sulphate solution (1 to 80) for one hour.

Plot III—Ends of sets dipped in coal-tar.

Plot IV—No special treatment.

The plots were manured with 200 maunds of unrotted cow-dung (a manure which is known to attract white-ants to the field where it is used). Some time after germination each plot was examined and many sets were found attacked by white-ants: generally the attack had commenced at the ends except in the case of those dipped in tar, in which the middle was attacked.—

No. I showed	40 per cent.	germination.
„ II	35	do.
„ III	36	do.
„ IV	38	do.

In no case did the treatment produce any material result.

CHAPTER II.

Utilization of Barren Lands.

Tree-planting.—The plantations continued under observation and little fresh planting was done as the number of trees is ample for experimental purposes. The unpromising condition of the large *babul* plantation at Abbaspur was noticed in last year's report. A recent examination shows that about 21 per cent. of the trees planted are thoroughly healthy: about 39 per cent. are alive but more or less stunted, and about 40 per cent. have died. It will be remembered that the object of this plantation was to test on a commercial scale the possibility of using *usar* land for supplying bark to the Cawnpore tanneries. The trees have been planted and tended with great care, greater perhaps than would be possible in an ordinary enterprise, and the number of trees lost is already so great that there is no hope of the plantation paying. I consider the result of this experiment definitive, and that the hope of afforesting large areas of *usar* with *babul* must now be abandoned, though here and there it may be possible for a landholder to pick out pieces of land which can be planted successfully.

The small experimental plantations at Gursikaran and Juhi have made satisfactory progress on the whole; at the latter place it is noticeable that the *dhak* (*Butea frondosa*), after growing very slowly for several years, has suddenly

developed most vigorously. The *mahuas* at the same place are still doing well, but the trial of these trees is a very tedious affair owing to their slow rate of growth: even the oldest trees cannot be expected to flower for twelve or fifteen years yet, and until then it will be impossible to form an opinion as to the success of the experiment. The rain-trees planted in 1902 are doing well and making exceptionally rapid growth.

Removal of alkali by subsoil drainage.—The flow from the drains was measured during the year. At the beginning of the season the drains were working satisfactorily, but the flow diminished as the season progressed, and the heavy rain of October yielded comparatively little. This year there has been no flow, and I have just ascertained that the drains have again silted up. The water was analysed and shown to contain considerable, but decreasing, quantities of soda salts. The effect of their removal is not yet noticeable on the land itself as the seed sown in October did not germinate.

Drainage by perforation.—This experiment failed. Despite all possible precautions the drainage holes choked in the first season, and after examining them in consultation with the Deputy Director I decided that it was useless to make further trials until a better protection for the tops of the holes could be devised: the particles of *usar* soil are so minute that they will travel almost wherever water can go, and will silt up any hole.

Removal of alkali by scraping.—The treatment of this plot was continued, and the alkali removed twice during the year at a cost of Rs. 4-1-0, bringing the total cost incurred so far to Rs. 15-7-0 per acre. The scrapings of the past year have not yet been analysed, but a rough calculation from the analysis of previous scrapings suggests that up to June 1903 alkali had been removed at the rate of about 40,000 lbs. per acre; probably at least as much more remains on and in the plot. The experiment will continue: it is at least very much cheaper than any other method of removing alkali that has been tried.

Use of gypsum.—One of the minute plots treated with gypsum in 1897 has, after a long rest, proved thoroughly reclaimed: in 1904 it yielded wheat at about 1,500lbs. per acre. This is interesting as confirming American results, but the cost of this treatment is prohibitive (*vide* page 445, *Agricultural Ledger* No. 13 of 1901). In this particular case 442 lbs. of gypsum were applied to 16 square yards of land, being practically 60 tons to the acre; this amount would cost at least Rs. 1,200, which far exceeds the maximum of capital that can be invested with profit in this country. The trials can therefore have no practical results till supplies of gypsum are brought within easy reach of the alkali plains.

Burning.—After consultation with the Deputy Director I have decided to abandon this trial. The small plot burnt was, it is true, improved, but it was not by any means wholly cured, and the poverty of the soil in organic matter made it necessary to use an amount of fuel that must prevent the operation from being profitable.

Liming.—The plot which had received six tons of lime per acre did not yield so well as in the previous year, the outturn of wheat per acre being as follows:

	1903.	1904.
	lbs.	lbs.
Kharíf ploughed in	352	224
Kharíf removed	288	192

The more heavily limed plot (eight tons per acre) was again sown with *juar* and *manduá* and despite a very bad season yielded about the same as in the previous year.

There is no doubt that the lime has made a difference in both plots, and it is now time to use some manure on them.

Ploughing in green crops.—It was remarked last year that lateness of the rains is particularly injurious to this experiment. The season of 1903 was from this point of view much the worst of which we have had any experience, as it was not possible to sow until August. There was thus very little green stuff to plough in, and there was not time for proper tillage. The outturns of rabí were accordingly very bad: it is unnecessary to print them as the conditions were wholly abnormal.

Trials of new plants.—*Cassia auriculata*, both sown broadcast and transplanted, was an entire failure in the alkali soil of Gursikaran. The same plant is doing well at Juhi where sown in *thálas*, but the broadcasted plot is not promising.

Of the saltbushes tried, *Atriplex semibaccata* entirely failed to germinate in alkali soil : a few plants raised in good soil and transplanted into alkali soil are alive but are not promising. Transplanted *Atriplex elegans* grew in alkali soil and produced seed. Two plants of *Atriplex natalii* are living but have produced no seed, while the *Atriplex canescens* has died out. These results agree generally with conclusions drawn from the trial of other plants of the same genus ; it may occasionally be possible to keep a few plants alive, but they do not thrive in the bad alkali under existing conditions of climate.

Trials of the saltworts which thrive in other parts of India, were begun during the year in accordance with the advice of the late Reporter on Economic Products. All the kinds tried failed to germinate on alkali soil at Gursikaran : the names are given on the margin.* At Abbaspur, where the soil is not so alkaline as at Gursikaran, though it is alkaline to the point of sterility, *Haloxylon recurvum* grew fairly well and a few plants seeded : and one or two plants came up of *H. multiflorum*, *Suaeda maritima* and *Salsola fœtida* : but germination was very poor. At Juhi, where the soil is not seriously alkaline, germination was much better and the different varieties are growing but have not yet seeded. These results are curious : the germination at Juhi shows that the seed was not defective, and as these plants ordinarily thrive on alkali they should (if anything) have done better at Gursikaran than at Juhi.

* *Kochia indica.*
Salsola fœtida.
Haloxylon multiflorum.
Haloxylon recurvum.
Suaeda maritima.

Hay-making.—Some interesting experiments on the value of *usar* hay were carried out during the year. The hay was made from the ordinary grasses growing on the *usar* (of which the commonest is *Sporobolus arabicus*). The object of the experiments was to determine whether the hay could be stored for a length of time, so that the surplus of good years could be carried over, and also to ascertain its feeding value after storage. The hay was stacked in the ordinary way in December 1901 and the stack was opened in December 1903. About 75 per cent. of the original weight of the stack was found to be in good condition, and chemical analysis showed its composition to be superior to the ordinary hay of the country. The results of the analysis and the remarks of the Agricultural Chemist are given below :—

	Per cent.	
Moisture	9·78	*Remarks.*—This hay is of better quality than most Indian hay and contains an especially low proportion of woody fibre.
Oil and wax	1·14	
Albuminoids	3·50	
Soluble carbohydrates	55·71	
Woody fibre	20·39	
Soluble mineral matter	4·74	
Sand	4·74	
Total ...	100·	
Total nitrogen	0·63	
Albuminoid	0·56	

The hay was then fed to various animals, and confirmation was obtained of our previous experience, that while cattle do not like the hay when they first see it, they soon get accustomed to it. Careful feeding tests were made with two cows (both strangers to *usar*-country), the diet being varied from time to time and the resulting yield of milk noted : the figures pointed to the conclusion that the hay could be substituted for *juar*-fodder in a proper ration without seriously diminishing the yield of milk. It may be safely concluded then that *usar* hay, properly made and stacked, may prove a valuable asset ; but each land-holder must determine for himself whether it will pay him to make hay from the land which is not required for grazing at the end of the rains.

CHAPTER III.

Experiments in Bundelkhand.

Experiments were begun under the orders of Government to test the practicability of (1) growing rice with canal water, (2) killing *kans* grass by flooding. The experiments were carried out in the Jalaun district.

Rice growing.—Rice is little grown in this part of Bundelkhand, and its introduction would be beneficial as increasing the variety of kharíf crops (at present almost limited to *juar*, cotton and *til*), while the Irrigation Department would find a use for some of the water that at present runs to waste during the kharíf irrigation season. The experiments made in 1903 were preliminary and tentative, while the lateness of the rains delayed sowings very seriously, so that it is not desirable to print the detailed results of the large number of varieties tried ; but some facts of importance were ascertained.

(*a*) Of the methods of sowing practised in the duáb, that known as *dhuriya* (sowing as soon as the ground is moistened) is practicable : that known as *leo* (sowing when the ground is soaked) is impracticable in the heavy soils as the cattle cannot draw the plough : while transplantation, though practicable, involves so much labour under unpleasant conditions that there seems to be very little chance of its adoption by the ease-loving people of Bundelkhand.

(*b*) The risk of insect pests appears to be very great. The majority of the varieties tried were attacked and injured seriously by the rice sapper, and it was noticeable that the finer varieties suffered most. This was not an exceptional occurrence, for I find that in some experiments in rice-growing carried out by the Irrigation Department a few years ago the same insect caused great harm, and no benefit was derived from the indigenous remedies tried (which indeed were charms rather than remedies). Apparently, therefore, if rice is to be grown in this region it will be necessary to confine attention to those varieties which the sapper does not attack, a serious limitation in the range of the experiment.

The trials are being continued this year on a greater variety of soil.

Kans killing.—The possibility of killing off *kans* by keeping the land flooded has been discussed from time to time for many years past, but no systematic experiments have been recorded. Last year four plots infested with *kans* were taken up and substantial embankments erected. It was hoped that it would be possible to keep the plots under water continuously from the beginning of July to the end of the cold weather, but the lateness of the rains caused serious delay at the outset, and breaches in the embankments (which must be looked for at first) interfered with the continuity of the experiment. No improvement was noticed as the result of the first year's work. The same plots will remain under treatment during the current year.

CHAPTER IV.

Entomological Notes.

The Deputy Director has continued his detailed study of insect pests. The following notes record some important observations :—

INSECTS ATTACKING COTTON.

A. Caterpillars boring into the bolls.—Three species have been observed :—

I.—About $\frac{1}{2}$″ long when full grown with orange spots near the head, pale-greenish line along the back, with brown and orange laterally.

II.—Generally similar to I, only perhaps rather smaller.

III.—Reddish or pinkish in colour (almost white when quite young), about $\frac{1}{2}$″ long when full grown.

No. I. *Earias Fabia**.—(Fig. I, plate XII, page 208, volume V, No. 3, Indian Museum Notes.)

Moth.—Length 0·4″, wing expanse 0·9″, easily recognised by the green wedge-shaped band running lengthways down the centre of the fore-wing, the remaining portion being mostly a creamy white often with a red tinge. The upper surface of the thorax is also green with the hairs twisted into a little curl. Abdomen is silvery white.

Eggs.—Pale blue, $\frac{1}{50}$″ in diameter. Under the microscope they appear faintly striated and look something like a minute Chinese lantern.

Larva.—The typical markings are :—

Head—mouth parts dark, a small portion faintly greenish, the rest occupied by two large dark brown convex shining patches with a deepish groove between

* NOTE,—The larvæ of this moth never twist up and destroy the leaves of cotton as suggested on page 183, Vol. V, No. 3 of Indian Museum Notes.

them. The first segment behind the head has a shining plate with irregular dark brown markings; below the plate on each side a tubercle surrounded by an orange patch. Similar ones on the upper surface of the second and third segments from the head, most conspicuous on the third one. A pale-greenish or whitish irregular line running down the back with dark brown and orange markings laterally. Tubercles on each segment, each with a short hair; spiracles dark, oval; legs 6-8-2.

I have noted the following exceptions to the above:—

Orange patch below plate may not be present; some of the dorsal tubercles may be black, forming distinct spots on the light coloured dorsal line. Tubercles may be prolonged into spikes especially on second and third segments from the head, giving a spiky appearance to the insect. The whole body may have a reddish tinge or be a bluish green with the orange patches round tubercles and a little brown in the usual place. The markings naturally become fainter before pupation, but these exceptions in colour do not appear to be due to this.

The pupa is 0·4″ long. The head is blunt and rounded, abdomen tapering somewhat sharply towards the tail. The upper surface is a darkish red brown colour, shading to a yellow green below with yellowish wing cases.

The cocoon is felt-like, white or slightly brownish, $\frac{5}{16}$″ to $\frac{7}{16}$″ long, $\frac{1}{7}$″ wide, somewhat boat-shaped, the keel being uppermost.

Life History.—In the field the moth lays its eggs singly on the flowers, bracts, and leaves of the cotton plant. I have obtained forty eggs from one moth in confinement. The eggs hatch out in about four days and the young caterpillar just at first may often be found amongst the anthers which it may eat before boring into the ovary.

When attacked young, the immature bolls wither and apparently from this cause fall off; the larvæ then come out and attack larger bolls, boring into them and eating into the seeds. Even if the boll is attacked when nearly fully grown and should open, the fibre is stained more or less and may be altogether worthless.

When the larva is about to pupate it comes out and forms a cocoon on the boll or bracts, generally between the two. The period of pupation is from 8 to 11 days, but this period may be extended at least during the cold weather; one caterpillar I obtained and which pupated November 5th, did not come out as a moth till January 24th. This moth was full sized but quite pale in colour, the position of the green stripe on the wing being faintly indicated by merely a mark of the same shape. The moth lives five to six days. A record which I have kept shows the pest exists either in cotton or *bhindi* (Hibiscus esculentus) during every month of the year, the *bhindi* carrying it over from one cotton season to another. In September 1901 the larvæ of these moths were found boring into the upper portion of the young stems of the cotton plant, the terminal buds and leaves becoming black and dead. I have noticed this method of attack occurring again this year.* When this pest attacks *bhindi* the caterpillar is rather larger and plumper.

No. II. *Earias insulana.*

Moth.—Length 0·3″, wing expanse 0·8″. The upper surface of thorax and fore-wings are green and the green hairs on the thorax form a little curl. The wings are placed acutely, roof-shaped at rest, the edge of the upper wing being rolled over. The under surfaces of fore-wings are darkish and silvery and the fringe is green. Hind-wing silvery, fringe larger, under-surface of thorax and abdomen silvery white. Legs, palpæ and proboscis more or less speckled with red.

Eggs, larva and cocoon resemble those of *Earias Fabia*. The pupa is 0·3″ long.

Life History.—The method of attack is similar to that of *Earias Fabia*. The moth lays its eggs in the same place; they likewise hatch out in three or four days. The young larva is active, pale green with dark brown head with hairs scattered over the body. When full grown it also comes out to pupate, period of pupation about 11 days, may be a day or two less or sometimes considerably longer. Some eggs laid in confinement June 3rd hatched June 7th, larvæ pupated June 18th.

Treatment.—It is impossible to get at these borers inside the bolls, besides the damage is done, and the best way is to pick the infested ones at the beginning of the season and burn them. As the larvæ attack *bhindi*, and by this means the pest is carried over during the time cotton is off the field, it would be best not to

* NOTE.—In many of the horn heads I have found a small white cocoon containing a hymenopterous parasite.

grow this crop, especially if a man is going in for the longer and better staples, and in the case of the country cotton to grow them at least as far apart as possible. If the terminal shoots of the cotton plant are attacked, these should be cut off and burnt at once before the moth escapes and more injury is done to the bolls, the stem form of attack taking place before the bolls are formed.

No. III (not identified)—family *Teneidæ*.

Moth.—Size 0·25″ long, wing expanse 0·58″. Fore-wings narrow brown speckled and patched with black, sometimes being more black than brown, specially towards the tip of the wing where the black extends completely across in two fairly distinct bands. Hind-wings and abdomen speckled silvery. Upturned pulpæ with black bands; terminal joint spur-like. The long legs are also banded or speckled with black or brown, the tibia of the hind leg being fringed with longish hairs.

Larva.—About $\frac{1}{2}$″ long when full grown, pinkish or reddish in colour, head brown; legs 6-8-2.

Pupa.—$\frac{1}{4}$″ to $\frac{5}{16}$″ long, reddish brown, segments of abdomen distinct.

Life History.—The young larvæ bore into the bolls which fall off apparently from this cause when attacked young; and great injury is done to the larger bolls by eating out the seeds and staining the fibre. I have found as many as three larvæ in one boll, but there is usually only one. The length of larval life is very variable and may last at times for months. As an instance several larvæ collected remained in this state from October to April, May; others from March, April to the middle of June; a few pupate from time to time, but observations carried on both in and out of doors go to show that more active pupation occurs at particular times; I have found it chiefly so in January and July or August.

The larvæ generally pupate inside the bolls; less frequently they come out and pupate between the bolls and bracts, when they form a slight transparent cocoon. They may also be found amongst the picked unginned cotton as larvæ, or having pupated either in the hollowed out seed or amongst the fibre. They will also go into the earth to pupate, but it is not their general custom. The period of pupation is about 9 to 10 days. I have been unable* to find the eggs of this moth in the field and I have never been able to get any eggs from them when kept in confinement, although I collected at one time as many as two hundred larvæ and raised a large number of moths from these, besides others from time to time. I have not found these pests attacking any other plant except cotton; and they are carried over from one year to another either by stray plants left in the field, by allowing the trees to stand for a year in order to get a second crop in the hot weather, or by the hibernating larvæ mixed amongst the ginned or unginned seed.

Treatment.—The larvæ are not difficult to see if the seed is ginned and where the amount is small, picking over by hand avoids all danger; also if spread out in the sun ants will kill and carry off a good many larvæ. I made the following test with regard to the vitality of the larvæ, thinking perhaps that an hour submerged in cold water would kill them when the seeds could be spread out and dry again.

I. Seeds containing larvæ placed in cold water—

1 hour	}	Survived.
3 hours	}	
10 „	{	1 dead.
		1 died afterwards.
		2 others survived.

Seeds containing larvæ placed in hot water—

130°F for 10 minutes	}	none survived.
130°F „ 5 „	}	

On a large scale and where the seeds could be properly stored and cared for, carbon-disulphide would possibly be the best plan of killing the larvæ. But if cotton is not grown in or near the same field every year, double cropping is avoided, affected seeds destroyed, and volunteer plants rooted out, the pest, except perhaps in exceptional years, can be kept in check; but if these precautions are not taken, the pest is

* Note.—Since writing the above I have obtained the eggs, I believe, from a fresh supply of moth this year, which I placed under a large mosquito net with several cotton plants. The eggs were laid singly on the under-surface of young leaves, leaf stalks and buds. They are oval, minute, 0·512 m.m. by 0·256 m.m., marked with wrinkled lines and a few reddish spots. I have also found them since in the field. The larvæ hatch out in three or four days and are whitish with brown black head and plate. Like the two previous pests, just at first they do not appear to adopt their boring habits.

capable of becoming so bad as to ruin the whole crop, more especially if double cropping is attempted. In all cases where there are indications of these three borers becoming bad, the best plan is to pick all affected bolls and burn them; such bolls are fairly easy to see, there being always a hole through which the larvæ pass out their fæces, though this is sometimes covered by the bracts surrounding the base of the boll.

Speaking for the last two years at the Cawnpore Experimental Farm, No. III (*i.e.* red larvæ) have done the most damage; but at times the other two together have been equal in numbers; thus out of 80 bolls examined in April, seventeen bolls contained the red larvæ and fifteen either that of *Earias fabia* or *Earias insulana*; the remaining were empty but had been attacked.

B.—Sucking Bugs, Plant-lice, Bark-lice and Leaf-hoppers.

I.—Dysdercus cingulatus.—Family Lygaeidæ. (Figured page 57, Vol. III, No. V, Indian Museum Notes.) Closely allied to D. Suturellus which is well known as a cotton pest in the United States. Female about half an inch long, male rather smaller. Easily recognised by its bright red or vermillion colour with a black spot in the middle of each fore-wing and the white-transverse bands on the under-surface of the abdomen.

Eggs.—Smooth oval-ovate, milky white, about 1·280 m. m. long and 0·960 m. m. wide.

Life History.—During copulation the sexes unite and disunite two or three times and about 30 hours afterwards the female lays apparently from 60 to 75 eggs. These I have found laid on the ground, and in one instance loose inside the three bracts surrounding the flower. But the usual method is to lay them in some crack or small hole in the ground and the female may be seen buried as it were perhaps up to the thorax in an upright position while laying the eggs. The eggs are laid in a mass without any adhesive material. After laying the eggs, the female carefully covers them with earth drawing it back with the front legs and passing it under the body, often tumbling over with the effort when manupulating a small lump of earth. The eggs hatch out in 5 to 6 days. In their earlier stages the young insects are all red and are similar in shape to their parents excepting in the absence of wings. For a day or two they appear to remain close round the eggs, after which they ascend the plant and commence their attack. The injury to the plant is effected by the insect inserting the sharp beak-like-sucker into the shoots, leaves and bolls or into the cotton seeds if the bolls are open; thus it not only tends to weaken the plant by extracting the sap, but injures the seed and fibre as well as staining the latter. The adults exist all the year round, and the generations are numerous; the pest reaches its greatest numbers during the months of May, June and July, chiefly attacking *bhindi* at this time. I have seen as many as 30 bugs on one fruit and genarally they are more numerous than on cotton, except in the case where the cotton plants are allowed to stand over in the field after the usual cold weather pickings and a hot weather crop is taken in May when they can be seen gathered together on the bolls or running about the trees often in large numbers and undoubtedly do a good deal of harm. The following is a record of their appearance during the year:—

January—Odd adults on cotton.

February, March—On various crops copulating.

April—In increasing numbers young ones first noticed, adults copulating.

May, June, July and August—In large numbers on *bhindi* in all stages; adults copulating; great numbers seen also during June in jungle of mango grove.

September, October, November and December.—Adults copulating; all sizes; numbers vary, but fewer than in preceding three months; chiefly seen on cotton and *bhindi*; odd ones may be seen at times on mango trees, wheat, sugarcane, and on gourds and other crops. Mentioned as attacking cotton, bottle gourds (Lagenaria vulgaris), musk mallow (Hibiscus abel moschus) and cabbages (Brassica oleracea) in Vol. II, No. 1, page 44, and Vol. II, No. VI, page 166, Indian Museum Notes.

Treatment.—They are not easily picked by hand. If numerous so as to be crowded on the bolls, I have found pure kerosine finely sprayed over fairly effective. But the experiment was somewhat tentative. It does not apparently injure the trees or bolls at this stage, and the ordinary soap solution is not strong enough for the adults. A cheap tin spray the receptacle of which conveniently holds about ½

pint of kerosine, can be obtained, but when the bugs are few and scattered they cannot be thus effectively dealt with as too much oil and time is wasted, and so much oil may injure the trees. Moreover in small numbers they do little damage in a good healthy growing crop.

II.—Not identified. Family Lygaeidæ. This bug resembles somewhat the previous one, D. Cingulatus, but is duller in colour and the transverse stripes on the abdomen are dark, not white. The head and prothorax are shorter and broader; there is more than one black spot on each fore-wing and a distinct white oval spot on the membranous tips. Female 0·6″ long, male may be slightly smaller. Odd ones are seen all the year round on various crops, but more specially on *til* (Sesamum indicum) in August and later on cotton. They injure plants, as all these bugs do, by sucking the juices, but so far have never occurred on cotton in sufficient numbers to do any appreciable harm. Eggs very similar to those of D. Cingulatus.

III.—Oxycarenus lugubris.—Family Lygæidœ (figured page 32, Vol. II, No. 1, Indian Museum Notes). The full grown insect is about $\frac{3}{16}$ th of an inch long, the female being the larger; blackish brown except certain portions of the legs which are more or less whitish; the wings are semi-transparent; the head rather long and triangular; the abdomen shining; terminal joint of the antennæ slightly club-shaped. Superficially the insect is somewhat fly-like and not unlike the cinch bug *(Blissus leucopterus)* injuring wheat in America.

Eggs.—Minute, oblong, striate; length 0·850 m. m, breadth 0·224 m. m.

Life History.—The insects live at first in the flowers or may be found between them and the surrounding bracts, afterwards in the open cotton bolls. The eggs I have found laid on the seed itself or close to it amongst the fibre about six to eight in number; they are whitish at first, but as they approach hatching they have a reddish appearance due to the colour of the young insect inside. They hatched out in about 30 to 40 hours apparently. The young are brightish red at first with a white band across the back and there is a greenish red stage and a brownish red stage before acquiring wings and the blackish colour of the adult. There are several generations during the cotton season, the pest being carried over from one crop to another in the adult form, probably by stray plants left in a field, ratooned growths of cotton and on *bhindi* (Hibiscus esculentus) on which I have found them in considerable numbers. The real damage is done when the bolls open, the insect sucking the oil from the seeds and causing the cotton to mat together and become stained. They increase rapidly in numbers, completely infest the open bolls and are a much more serious pest than Dysdercus cingulatus as far as I have seen.

Preventive measures.—Don't attempt second crop of cotton, don't allow odd plants to remain in the field after the first season is over. Root out all cotton growing from old stumps. Avoid growing perennial tree cotton (which remains on the land all the year round) and plants belonging to the same family.

Treatment.—It is practically impossible to get at these insects when between the bracts and flowers, nor do they occur in great numbers till the bolls open. Spraying the affected bolls with kerosine emulsion from a small hand spray killed the bugs, but dust collected on the fibre and rather spoilt its colour. Pure kerosine was also tried: this quickly kills the bugs and dust does not collect so, but I have made no test as to its effect on the fibre and can therefore recommend nothing at present except the above preventive measures.

IV.—Plant-lice (aphis), Bark-lice and leaf-hoppers:—These three also attack cotton and appear as soon as it is up, the first and last doing the most harm, sucking the juices of the leaves and causing them to curl up and wither. With regard to the first there are a number of beetles and their larvæ and the larvæ of certain flies mentioned in last year's report which tend to keep them in check. They are all difficult to deal with, the aphis being on the under-surface of the leaves, the leaf-hoppers being minute and active and the bark-lice covered by a secretion (has not done any damage so far). Time does not allow me to go more fully into these pests, but it is important to have the land in good heart, so that the cotton trees are vigorous and able to outgrow the attack. If a liquid or powder is used to kill the aphis, the sprayer must be so constructed as to distribute the fluid or powder on the under surface of the leaves where the pest is situated. The leaf-hoppers are more harmful to American and Egyptian cottons than to the ordinary country variety; they also occur on *bhindi* in large numbers at times.

C.—Insects eating the leaves of cotton.

I.—Myllocerus maculosus.—Family Curculionidæ. (Figured Vol. IV, No. 3, plate viii, Indian Museum Notes). This is a whitish grey weevil with a pale bluish tinge, short furrowed snout, rather prominent, large black oblong eyes, prothoræ prominently constricted at the base, wing cases with dotted lines and a few dark irregular spots. The female is about $\frac{5}{16}$th of an inch long, the male somewhat smaller.

Eggs.—Not found.

Larvæ.—I have not been able to find them in flowers, bolls, buds or stems.

Life History.—The weevil first begins to be noticeable on cotton in July, eating round the edges of the leaves so as to give them frequently a notched appearance. When frightened they drop off the leaf or disappear quickly on the under surface. They sometimes rapidly increase in numbers and continue in evidence up till October-November, when only a few usually are to be seen. In January, especially if there has been a frost; I have only found one or two hidden between the bracts and bolls. February, March, April, May and June—I have not found any except one this year in March, which makes it probable that the pest is carried over from one cotton season to another by odd adults hidden away perhaps under clods or rubbish or on stray plants, as is the case with many other weevils. I have found them on *bhindi* in July-August. Other species of weevil (not identified) occur on cotton, but only odd ones and are not important.

Treatment.—If they increase so as likely to do considerable harm, the simplest plan is to pick them by hand or knock them off into a tin containing some kerosine and water. It is not expensive when done by boys and has been found sufficiently effective at the experimental farm. (See Bulletin No. 15, Agricultural Series.) This also mentions London purple* having been tried and found no good, but I have every reason to believe it was tried in such a manner as not likely to be successful. I hope this year, if the pest should occur in any numbers, to try the effect of spraying with arsenic and lime mixture: this should kill them by poisoning their food, and if effective, would probably be more suitable in the case of a large area then picking. But the rainy season may be such as to prevent its use. The principal points affecting results with such a mixture being (I) that the spray should be sufficiently fine to distribute the liquid evenly over the leaves and for it to remain on them so that on evaporation the poison will also be evenly deposited; (II) that rain shall not be falling, *i.e.* it should be done during a fine spell as the poison will be washed off otherwise and time and money wasted; (III) that the trees be not too young or the poison too strong as to injure the plant. The admixture of lime with arsenic is added to prevent this as much as possible.

II.—Sylepta multilinealis.—Family *Pyralidæ.* (Fig. Vol. V, No. 3, plate xiv and Vol. IV, No. 2, plate v, as *Synclera multilinealis*, Indian Museum Notes).

Moth.—Length 0·45″, wing-expanse about 1″. Fore wings covered with olive brown markings forming a net-work. Similar coloured curved lines on hind wing. There is an olive brown edging to the outer margin of all four wings with a finer line in the ciliá itself. Thorax with spots and abdomen with transverse bands of about the same colour with the exception of a dark patch on the tip of abdomen. Palpi and forelegs with brown bands.

Eggs.—Not found.

Larva.—About an inch long, rather slender. The head is blackish brown with two distinct black patches on first segment behind the head. The general colour is glassy green, bluish green or yellowish green on the upper surface, lighter green underneath; in others the dorsal surface may be distinctly reddish. There are a few longish hairs and the larva is fairly active. At some stages the subdivisions of the tracheæ radiating from each stigmata are very distinct. Legs 6-8-2, true legs black or with black bands.

Pupa.—Darkish red, about 0·6″ long, abdomen running quickly to a sharp point, tip dark.

Life History.†—I have not found out much about it. The larvæ generally make their appearance in August, the attack is at its height in September, and generally disappears with the commencement of the cold weather. It eats the

* NOTE.—A waste product obtained in the manufacture of certain dyes containing about 50 per cent. arsenic.

† I frequently find the white cocoon of a small hymenopterer in the rolled up leaves: it appears to be a parasite. The larvæ are also sometimes attacked by a bug.

leaves of the cotton plant and folds the leaves during the larval state (except when very young) as well as when about to pupate which it does beneath the folded-over leaf. The young larva may sometimes be seen letting themselves down from leaf to leaf by silken threads. In Bulletin No. 15, Agricultural Series, a bad attack is mentioned as occurring in 1900, an abnormally wet season, and it occurred to some extent in 1902. It is mentioned on page 132, Vol. V, No. 3, Indian Museum Notes, as feeding on the leaves of *bhindi* (Hibiscus esculentus) in Calcutta during July and August. I have not noticed it on *bhindi* in Cawnpore.

Treatment.—It has not occurred in sufficient numbers at the farm during the last few years to make any steps as to treatment worth while, and nothing is said in Bulletin No. 15, mentioned above, as to any treatment having been tried in 1900. Though with other pests picking and destroying them has been found most simple, the only other treatment worth trial would be the poisoning of the leaves with arsenic and lime as mentioned for weevils. I merely suggest this as the usual method of dealing with such pests, but so far I have had no opportunity of giving it a trial, and if the caterpillars should occur at their worst during abnormally wet seasons the rain would make this treatment useless by washing the poison off the leaves.

III.—Not identified.—Moth stout, length about 0·5″, wing expanse ♀ 1·4″ ♂ 1·1″ General colour ochreous, with a darkish longitudinal mark down head, thorax and part of abdomen. Under surface of body lighter.

On the fore-wing there are some zigzag dentate lines, the inner portion of wing is light ochreous, outer portion dusky, about the middle, towards the costal edge is a small white oval spot with dusky border. The outer edge of wing is dentate with a brown curved line which extends in distinct points along the veinlets a short distance. The ciliá is dark edged by white and purple scales. On the under surface there is a distinct diffuse dusky patch near the apex. Hind wings dusky, silvery above, testaceous below. The male is darker and its antennæ pectinated.

Eggs.—Not found.

Larva 1″ to 1·25″ long when full grown, looper like. Head generally yellow, lobes convex, colour of body greenish, but passes through various shades of green to yellow, the constriction between each segment yellowish. Seven fine white lines running lengthways of body consisting of minute disjointed lines and dots, central one situated on narrow dusky pulsating line. There are other separate white dots on each segment, sometimes with a black centre and with a fine hair from each. Immediately behind head they are arranged in two rows transversely. Legs 6-6-2 about same colour as the body, caudal ones well developed.

Pupa.—Stout, darkish red, 0·57″ long, head somewhat rounded with a little projection, tail end pointed.

Life History.—The larvæ appear on the cotton shortly after it comes up, and may be seen during July, August, September and October. They eat patches out of the leaves so that it appears perforated by a number of holes. They also attack *bhindi*. I have not so far found out much more about it. When pupating it rolls over one edge of the leaf and pupates beneath it. The period of pupation is 7 to 8 days.

Treatment.—So far it has never occurred in large numbers ; if this should happen, the treatment suggested for the previous caterpillar would be applicable. One or two other odd caterpillars occur which eat the leaves but are of little importance.

D.—Insects boring into cotton stalks.

I.—Sphenoptera gossypii.—(Vol. II, No. 1, page 33, Indian Museum Notes.)

Beetle.—Shining, metallic, pronounced brilliant copper colour on under surface. Length about 0·42″; width 0·13″; shape parallel; antennæ short, 0·13″ eyes prominent, head larger than thorax. Posterior legs (tibias) turned in.

Eggs.—Not known.

Larvæ, whitish yellow, legless grub about 0·4″ long. First 3 segments behind head swollen, especially the first. The caudal segment is lobed.

Pupa.—Pale yellowish white, length 0·35″.

Life History.—Has not been noticed at Cawnpore, but its attacks occurred at Nagpur. The beetle probably lays an egg in the stem near the root, the young larva tunnelling the inside as it grows, so that part of the main root and a few inches of stem are completely hollowed out with the exception of some sawdust of

a reddish colour. The plants in consequence die; a considerable number are reported to have been attacked. In injured plants sent to me all three stages were found with a small hole bored for the exit of beetle at the proper time.

Of the above pests the caterpillars boring into the bolls and the bug Oxycarenus lugubris are, I think, at least around Cawnpore, decidedly the worst. Myllocerus maculosus can also do a great deal of harm but is more controllable. Fortunately the cotton boll worm Heliothis Armigera which does so much harm to cotton in the United States, I have never seen in the cotton bolls here, though it does a great deal of harm to other crops in this country specially to gram. The leaf-hoppers do a good deal of injury in the early stages of the cotton plant and aphis at times are also troublesome, but except in exceptional years these other pests are injurious rather collectively than individually and cannot be compared, I think, with the boll caterpillars and O. Lugubris, which attacking the bolls strike at the most valuable part of the crop. These observations have been made round about Cawnpore and it is possible that in other parts or provinces some difference may occur.

CHAPTER V.

Miscellaneous.

1. *Wheat rust.*—Investigations were continued during the year by the Deputy Director, working in conjunction with the Cryptogamic Botanist, who will publish the results in due course.

2. *Wheat breeding.*—Further valuable experience of the behaviour of various strains of wheat was gained during the year, and a few of the new wheats appear to be promising, but they will have to be tested for some time yet. The trial grounds are beginning to incite interest among the cultivators both at Cawnpore and at Orai; they give their opinions freely as to the value of particular wheats and sometimes ask for a few seeds to try in their own fields. Their co-operation is of course cordially welcomed.

3. *Drought-resisting fodder plants.*—The only observations to add to those recorded last year are:—

(*a*) *Atriplex semibaccata.*—Some of the plants survive and seed freely, but the plants do not reproduce themselves though the ground round them is kept in good order. I have noticed that ants carry away the ripe seeds as soon as they fall, a fact which goes far to account for the absence of reproduction, and at the same time to condemn the plant as unsuitable for this country.

(*b*) *Chenopodium auricomum.*—All the plants died off in their second hot weather, and at no time was the growth sufficient to yield an appreciable supply of fodder. Speaking generally none of the exotics tried give any indications of being suitable for introduction in these provinces.

(*c*) *Paspalum dilatatum.*—This grass, which has so great a reputation as a drought-resister in Australia, has definitely failed at Cawnpore. It was kept alive for some time by weeding and frequent irrigation, but never gave a crop at all comparable to what our indigenous fodders would yield with the same care; and when left to itself it was promptly smothered by other vegetation and has now entirely disappeared.

4. *Nitrogen investigation.*—Samples of rain water and drainage water were collected during the year, and sent to the Agricultural Chemist for analysis, but the results have not yet reached me. The working of the drain-gauges has been somewhat irregular, and it is not yet possible to make any calculations of the losses to the soil caused by drainage.

5. *Sugar boiling.*—The boiling plant has been developed during the year into a really practical factory; an account of it will shortly be published as a bulletin. The native processes of refining require further study before practical improvements can be suggested.

6. *Well sinking.*—The experimental well for use in places where there is no clay stratum (*mota*) is still under construction. I am building it at Gházipur where it has the benefit of supervision by the inventor, Mr. Molony, and I hope it will be ready for irrigation in the cold weather.

Digitized with financial assistance from Hemendra Kothari on 24 February, 2020

APPENDIX No. I.—*Amount of rainfall at the Cawnpore Farm in* 1902-1903 *and* 1903-1904.

Month.		1902-1903.		1903-1904.		Average rain fall of eight years 1891-1899 in inches.
		Rainy days.	Rainfall in inches.	Rainy days.	Rainfall in inches.	
June	First half	1	·14	1	·18	3·57
	Second half	...	...	3	1·72	
July	First half	6	2·45	...	...	9·60
	Second half	9	4·57	2	·77	
August	First half	4	1·02	6	3·76	13·61
	Second half	2	·77	3	4·57	
September	First half	9	13·125	4	3·79	6·23
	Second half	3	·65	3	1·245	
October	First half	...	...	10	10·105	1·73
	Second half	...	...	...	...	
November	First half	...	..	...	...	·48
	Second half	...	...	...	...	
December	First half	...	...	...	...	·27
	Second half	...	...	...	...	
January	First half	..	...	...	·04	·64
	Second half	...	...	...	·07	
February	First half	...	...	...	...	·50
	Second half	...	...	...	·04	
March	First half	..	...	2	·27	·05
	Second half	...	...	...	...	
April	First half	..	...	...	·01	...
	Second half	...	...	...	...	
May	First half	..	...	1	·19	·33
	Second half	..	...	1	·23	
		34	22·725	36	26·99	

APPENDIX No. II.—*Mean-temperature at the Cawnpore Experimental Farm,* 1903-1904.

Month.		Under shade.		In the open.		Remarks.
		Maximum.	Minimum.	Maximum.	Minimum.	
June	First half	103·63	85·7	116·16	82·4	
	Second half	100·16	84·0	111·3	81·7	
July	First half	103·6	87·26	112·86	83·26	
	Second half	93·9	82·56	102·21	80·93	
August	First half	88·5	80·06	96·73	87·25	
	Second half	87·25	79·21	99·28	77·53	
September	First half	87·3	78 66	101·43	76·73	
	Second half	87·73	78·26	107·1	75·93	
October	First half	79·86	74·7	91·23	73·2	
	Second half	84·87	68·84	108·71	64·15	
November	First half	80·0	59·50	109·60	52·75	
	Second half	75·50	56·36	109·0	47·25	
December	First half	69·96	51·70	107·33	43·73	
	Second half	67·46	50·15	98·50	43·03	
January	First half	68·1	50·73	103·33	44·13	
	Second half	69·86	53·26	98·83	46·93	
February	First half	71·93	50·31	98·6	43·60	
	Second half	78·07	57·5	107·28	50·71	
March	First half	78·86	60·2	100·7	52·86	
	Second half	92·12	65·50	111·25	56·0	
April	First half	99·40	72·13	117·0	65·0	
	Second half	102·73	76·93	115·26	65·6	
May	First half	103·73	80·53	122·8	74·40	
	Second half	100·12	80·5	118·18	73·75	